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WHAT IS CLAIMED IS:

1. A method for increasing throughput for a wireless transmission comprising the step of:

   a. gathering QoS requirement of each wireless transmitting entity at wireless medium resources coordinator;

   b. performing medium resource scheduling base on the QoS requirements of each wireless transmitting entity that are being gathered by wireless medium resources coordinator;

   c. performing medium resource dedication base on the schedule that are being generated by wireless medium resources coordinator;

   d. setting up a transformation process at each wireless transmitting entity that is used to convert bit streams into transmission signal;

   e. transmitting signal and pilot symbols at the beginning of a transmission in order to facilitate all receiving devices to estimate the channel response on the transmission signal of each transmitting antenna and perform necessary setup for decoding data payloads that are being transmitted;

   f. performing aggregation before transmission for data units that are being queued at MAC of a wireless transmitting entity, which are targeted for the same recipient; and

g. performing aggregation during transmission for frames that are being queued at a wireless transmitting entity, which are waiting for transmission opportunities.

2. A method for identifying medium resources in a wireless medium that is being used to achieve high throughput wireless transmission comprising the step of:

a. determining the minimum number of antenna that is available at all targeted receiving entity of a transmission;

b. identifying each transmitting antenna with an index that is going to be used for the transmission;

c. determine the number of distinct set of frequency sub-carriers that is being formed for the transmission;

d. assigning a unique ID for each set of frequency sub-carriers that is being formed for the transmission; and

e. combining the unique ID for a set of frequency sub-carriers with the index of a transmitting antenna to form a unique ID, which is used to identify an instant of medium resource.

3. A method as claimed in claim 1, wherein said step for performing medium resources dedication comprises the steps of:

a. obtaining a periodic interval that is used to generate medium dedication frames for all wireless transmitting

entities;

b. obtaining a list of number of instances of medium resource that can be utilized by each wireless transmitting wireless;

c. obtaining a list of duration for each medium dedication that is required by each wireless transmitting entity; and

d. obtaining a list of number of medium dedication frames required by each wireless transmitting entity in order to achieve their respective QoS requirement in each of said periodic interval.

4. A method as claimed in claim 3, wherein said step for obtaining a periodic interval comprises the step of:

a. determining, for each wireless transmitting entity, a minimum delay tolerance measuring at MAC SAP of all data units that are originated from the wireless transmitting entity;

b. determining, for each wireless transmitting entity, a minimum number of dedication required within the duration of said minimum delay tolerance measuring;

c. computing, for each wireless transmitting entity, a number of dedication required within the duration of said minimum delay tolerance measuring in order to satisfy QoS requirement of respective station;

d. computing a first minimum among all the minimum

delay tolerance divided by the number of dedication required for each wireless transmitting entity;

e. computing a second minimum among all the minimum delay tolerance divided by the minimum number of dedication required for each wireless transmitting entity; and

f. choosing a value that is greater than or equal to said first minimum and less than or equal to said second minimum.

5. A method as claimed in claim 4, wherein said step for computing a number of dedication comprises the step of:

a. determining a value for the specific interval that is used to compute the number of dedication;

b. determining a maximum duration that is allowed or pre-configured for each instant of medium resource dedication;

c. computing a required duration that the wireless transmitting entity requires to be dedicated with medium resources within the specific interval in order to satisfy its QoS requirement; and

d. computing an upper bound of the division of said required duration over said maximum duration.

6. A medium dedication frame for use in an apparatus for performing medium dedication, said medium dedication

frame comprising:

a. a frame header having standard fields for identifying the frame;

b. a duration value for indicating a duration of each dedication;

c. a resource dedication map for indicating a mapping of medium resources to each transmitting entity; and

d. a frame checksum for checking the integrity of the content of the frame.

7. A medium resource dedication frame for use in an apparatus for performing medium dedication by medium resource coordinator which is to indicate medium resources mapping, said medium resource dedication frame comprising:

a. a unique ID used to identify an instant of medium resource or a group of medium resources;and

b. an entity ID used to identify a wireless transmitting entity.

8. A method for facilitating parallel transmission, each transmission required to be transmitted in the format in order for all receiving entities to obtain knowledge of the channel response relatively to each corresponding transmitting antenna and setup decoding processes, said method comprising:

a. sending a preamble that is used to synchronize all receiving device of this transmission;

b. sending a signal that is used to provide necessary information for all receiving device to perform channel estimation for each transmitting antenna and to decode data payload.

c. sending a list of training sequences, each being transmitted by a corresponding transmitting antenna; and

d. holding bit streams to be transmitted.

9. A method as claimed in claim 8, wherein said signal comprises:

a. information indicating a number of transmitting antenna that will be active in the same frequency domain during the data payload transmission;

b. information indicating a mode of transformation that is being used during the transmission of the data payload; and

c. information indicating a duration value that is used to indicate the duration of the transmission.

10. A method as claimed in claim 9, wherein said mode is selected from a list of transformation modes that is being apply to each set of frequency sub-carriers.

11. An apparatus for converting a bit stream to transmission signals that are to be transmitted in parallel using multiple antennas or multiple sets of frequency sub-carriers comprising:

a. a bit streams divider that fragmenting a bit streams to multiple fragments.

b. a series of transformers that are grouped and used to perform transformation on each fragment, which is the output of said bit stream divider in order to construct transmission signal; and

c. a frequency and antenna distributor that is used to distribute each transmission signal that are frequency coded based on the index of the signal to an antenna for transmission.

12. An apparatus as claimed in claim 11, wherein said bit stream dividercomprises:

a. means for determining the number of transmitting antennas that are to be used by the transmitting entity for the transmission;

b. means for dividing the bit streams into multiple numbers of sub streams with the number equal to the value determined by said determining means;

c. means for subdividing each sub stream into multiple numbers of segments, each segment being equal to a predetermined size that is to be represented by an

OFDM symbol.

d. means for fragmenting each segment into multiple numbers of fragments, each fragment being equal to a predetermined size that is to be frequency coded.

13. A method for adding a label each fragment that is being produced by the bit stream divider, by index referencing, said method comprising the steps of:

a. adding an index that is used to indicate the sub stream that the fragment belongs to;

b. adding an index that is used to indicate the sequence of the fragment in a segment of a sub stream;

c. adding an index that is used to indicate the sequence of a segment of a sub stream that the fragment belongs to.

14. An apparatus to perform transformation on each fragment to generate a transmission signal that is frequency coded, comprising:

a. a signal controller for providing a coordination signal for other units;

b. a gate controller for controlling the time that the input is to be processed;

c. a transformation unit for performing transformation on the input in order to produce an output that is more error resistant;

d. a frequency assignment unit for obtaining the frequency for representing the signal;

e. an antenna assignment unit for determining an antenna which is used to transmit the output signal.

【書類名】外国語明細書

SPECIFICATION

TITLE OF THE INVENTION

Method and apparatus to facilitate categorization of medium resources for multi-antenna wireless system

FIELD OF THE INVENTION

The present invention relates to the method and apparatus to facilitate categorization of medium resources for multi-antenna wireless system to achieve high throughput wireless transmission.

BACKGROUND OF THE INVENTION

In prior art, means to achieve high throughput are being introduced. Although these means can be employed in multiple antenna system, but means to categorize each instant of medium resource to perform schedule and coordination in order to achieve high throughput in a more efficient manner are not being described. Furthermore, a systematic manner to enhance from the existing system is not being illustrated.

SUMMARY OF THE INVENTION

[Problems to be solved by the invention]

In multiple antennas system, multiple antennas can be activated in the same frequency at the same time to facilitate parallel transmission, with the limitation that the number of transmitting antennas cannot be greater than the number of receiving antennas. In order for a receiver to receive and decode those parallel

transmissions, the channel response of each corresponding transmitting antenna must be known by receiver. So, before information bits are being transmitted, the pilot symbols are required to be transmitted in order to obtain awareness and provide information for receiver to estimate the channel response. Furthermore, more reliable channel coding and methods to increase throughput efficiency are required in order to compensate the effect introduced by higher order modulation.

[Means for solving the problems]

The invention solves the problems by providing a systematic processes to enhance from the existing system in order to achieve high throughput transmission; a means to classify medium resources and identify each instant of medium resources using a unique ID in order to facilitate medium resources scheduling and channel estimation; a means to perform medium resources scheduling in order to abstract and produce information that are to be used for performing medium resources dedication; a means to provide necessary information to receiving entity in order to facilitate decoding of streams that are transmitted by multiple transmitting entities in parallel using multiple antennas; an apparatus that is capable of dynamically change transformation mode on bits stream in order to produce transmission signal base on each transmission setup; a means to transmit each sub streams that are divided from a bits stream in parallel using multiple antennas or multiple sets of frequency sub-carrier as well as a means to transmit a bits stream in

a more reliable manner using multiple antennas or multiple sets of frequency sub-carrier.

With the present invention, QoS requirements of wireless transmitting entities are being acquired by a medium resources coordinator, which are then used as inputs to a medium resources scheduler to generate medium dedication schedule. At each fix dedication interval, medium dedication frames are being generated and transmitted to each wireless transmitting entity. It dedicates wireless transmitting entities with medium resources for a specific duration. The wireless transmitting entity that owns a special medium resource is required to perform transmission setup. After the setup, each transmitting antenna is required to transmit a sequence of pilot symbols in sequence in order to facilitate all receiving entities to be able to estimate the channel response of each corresponding transmitting antenna. This is required in order to be able to decode transmission signal successfully. Then, each transmitting entity can start transmission in parallel. A bits stream that is to be transmitted is being processed by an apparatus, which convert bits stream into transmission signals that are more resistant to channel errors.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following description, for purpose of explanation, specific numbers, times, structures, and other parameters are set forth in

order to provide a thorough understanding of the present invention. The following paragraphs give an exemplification of how the invention can be implemented. However, it will be apparent to anyone skilled in the art that the present invention may be practiced without these specific details.

To help understand the invention easier, the following definitions are used:

- The term "Data Train" refers to a MAC protocol data unit that consists of multiple data units that are being kept in compartments individually.
- The term "Transmission unit" refers to a series of transmission that is initiated by only one transmitting entity. In a Transmission Unit, it can consist of one or more physical layer protocol data units.
- The term "WM" refers to the Wireless Medium.
- The term "QoS" refers to Quality of Service.
- The term "MAC" refers to Media Access Controller

In the today communication market, the use of Wireless Local Area Network (WLAN) technology is growing at rapid pace. With more and more applications targeted to be delivered using wireless technology, it has created a force to increase the data rate of wireless transmission. This can be achieved by increasing the bandwidth of a wireless channel, employing higher order modulation techniques, utilizing advance channel coding and facilitating parallel

transmissions. These techniques permit more data bits to be transmitted during an instant of time duration which required changes to the physical layer implementation or transceiver of existing wireless equipment. Besides these changes, the format and method that a transmission unit is formulated required to be revolutionized otherwise it will reduce the throughput efficiency significantly.

As shown in Figure 1 is a processes flow diagram that represents the mandatory processes that are required to achieve significant and sensible throughput increment that is measuring at MAC SAP. Those processes are Resource Scheduling (101), Medium Resource Dedication (102), Resource Activation & Setup (103) & Transmission (104). The operation started by a medium resource coordinator to gather and collect QoS requirement and transmission capabilities of each transmission entity. The detail description of this process can be found in a Japanese Patent application 2003-313997 filed on September 5, 2003 by the same applicant as the present application. Japanese Patent application 2003-313997 is herein enclosed by reference. Using that information as input, a Medium Resource Dedication Schedule for each transmitting entity is being generated. Then, medium resources are being dedicated to each transmitting entity base on it corresponding schedule to facilitate transmission in order to fulfill their respective QoS requirement. Transmitting entity that is being dedicated with specific resources is required to initiate the transmission and transmit necessary information in order to

understand the transmission. Each transmitting entity that are being dedicated with resources for transmission have to train all wireless receivers such that there are capable to receive and decode bits streams that are being transmitted using the medium resources that are being dedicated. After resource setup and activation, data payload that may contains aggregated data units are being processed and transmitted.

The current highest transmission rate that can be achieved by existing WLAN equipment is very limited in range space. With the use of multiple antennas system, concept of spatial multiplexing and diversity are being introduced. Throughput of the system can be increased without increasing the frequency bandwidth and longer transmission distance can be achieved with an acceptable BER. Figures 2 and 3 show a simplified OFDM transceiver that is associated with each antenna for a MIMO configuration. Figure 2 shows the transmitter and Fig. 3 shows the receiver. The box 100 in the Figure 2 is performing core operations in order to achieve higher throughput and more reliable transmission. An overview of the operations to be performed is shown in Figure 9. Figure 8 shows a system that is performing the operations. It consists of a Bits Stream Divider (511), a Transformer cluster (512), a Frequency & Antenna Distributor (513) and an IFFT cluster (505). The input for the Bits Stream Divider is a variable or fix size unit that is to be transmitted, which is represented in bits stream format. The input bits stream is to be divided into multiple sub streams. At each fix interval, a

segment from each sub stream is used to construct fragments. Label each fragment as X_{ijk}, where k is the index to a sub stream that is starting from 0, i is the index to a segment within a sub stream that is starting from 1 and j is the index to a fragment within a segment that is starting from 1. Each fragment is to be used as an input to a fragment converter, which consists of a group of transformer. The number of transformer in each fragment converter is depending on the type of transformation that are to be performed on each fragment in order to generate transmission signals. For an example, the type of transformation can either be spatial multiplexing, space time coding, space frequency coding or any other coding that enhances the error resistance of the signal generated. It can also be a combination of multiple transformations as mentioned or not listed to generate the final transmission signal. Each transformer in a fragment converter is associated with a frequency and an antenna. The output of a transformer is a transmission signal that is frequency coded, which is then distributed to a pipeline that is associated with an antenna by Frequency & Antenna Distributor.

Each Transformer consists of a gate controller (301), a transformation unit (302), a Frequency Assignment unit (303), an Antenna Assignment unit (304) and a Signal Controller (305). The gate controller is used to activate or deactivate the operation of the transformer. If a transformer is activated, then the input signal is to be processed in order to generate an output that is to be combined with other outputs for transmission. If a transformer is deactivated,

then the input signal is ignored and an NULL output, which is having no effect when combine with other outputs, is generated. The Transformation unit is to perform a transformation on the input signal in order to produce an output signal that is more resistant to error. The Frequency Assignment unit is to assign a frequency that is used to code the signal that is being processed by the Transformer. The Antenna Assignment unit is to assign an antenna that is to be used to transmit the output signal. The Signal controller is to provide coordination signals for the other four units. A graphical representation of Transformer is shown in Figure 4. Each output of a Transformer is connected with Frequency & Antenna Distributor (513). The function of Frequency & Antenna Distributor is to distribute the input signal to an IFFT input port of an antenna according to its frequency representation and antenna index that is being assigned to the signal. Each IFFT (505) is associated with an antenna, which contains f_{n_g} number of input ports. f_{n_g} is the number of frequency sub-carriers that are available for transmission. Each input port is being assigned by Frequency & Antenna Distributor a frequency coded signal that are to be combined with other signals from other input ports to generate a time domain transmission signal.

To transmit a bits stream, S, first it must be divided into n_a number of sub stream with each sub stream being denoted by S_i where $i = n_a - 1$. Then each sub stream, S_i, is to be further sub divide into n_s number of segment. Each instant of the segment is to be fragmented

into n_f number of fragment. A fragment, represented by X_{ijk} as shown in Figure 5, is to be used as an input for a fragment converter. X_{ijk} is representing the $fragment_j$ of $segment_i$ that is belonging to sub stream S_k. X_{ijk} is to be coded in frequency domain and carried by a frequency sub-carrier in order to facilitate transmission. Figure 5 is a pictorial representation of the relationship between bits stream, sub stream, segment and fragment that are being mentioned above. The detail operations to be performed by Bits Stream Divider to generate fragments are shown in Figures 6 and 7. As shown in Figure 6, at step 1, the bit stream S is divided into sub streams. At step 2, each sub stream is divided to construct multiple segments. At step 3, at each fix interval, the first unprocessed segment of all sub streams is being fragmented into multiple fragments.

First is to determine the number of antennas in this transmitting entity that are to be used to transmit the bits stream, hereby denoted it as a_n (571) and the number of sub stream to be transmitted by each antenna, hereby denoted it as S_n (572). Then, divide the bits stream into $a_n * S_n$ units of sub streams (573). After the division, determine the number of bits from a sub stream that a fragment converter is needed as an input at each interval, hereby denoted it as P_n (574). Then divide each sub stream into Q segments, with the size of each segment from a sub stream being equal to P_n (575). Finally, determine the number of bits from a segment that are to be coded or transformed independently, hereby denoted it as R_n (576). Then divide each segment into T fragments, with the size of each

fragment size from a segment being equal to R_n (577). The $segment_i$ of all sub streams are to be processed in parallel and transmitted at the same instant of time. The $segment_i$ and $segment_{i+1}$ of the same sub stream are to be processed in sequence.

In the initialization stage of the system, three system parameters such as n_a, n_f and n_g are to be determined. n_a is the number of transmitting antennas that are to be used by the transmitting entity to transmit the input bits stream that is processed by the system. n_g is the number of frequency sub-carriers that are available in the channel that is used for the transmission of the bits stream. n_f is the number of frequency sub-carriers that are being selected to encode a segment of the stream. n_f is less than or equal to n_g and n_a is less than or equal to the number of antennas associated with the transmitting entity. After those numbers are determined, fragment converters are to be formed. The input for a fragment converter is the output of the Bits Stream Divider, which is a fragment of the bits streams that are to be transmitted. This input is propagated to each transformer in a fragment converter. Each transformer is associated with a frequency that is used to code the output signal and an antenna that is used to transmit the output signal. The number of transformers in a fragment converter is depending on the transformation that are to be employed on the signal. The total numbers of fragment converters in the system is bounded by $n_a * n_f$.

In order to achieve better understanding and ease the explanation,

an limited version of the system is the following explanation For examples, to perform space frequency coding or space time coding, each fragment converter consists of n_a units of Transformer. If all those transformers in fragment converter are being assigned with different frequencies and associated with different antennas, spatial frequency coding can be performed on the input signal. In this case, n_f is equal to n_g divided by n_a. If all those transformers in fragment converter are being associated with different antennas but being assigned with the same frequency and output of those transformers is time controlled, space time coding can be performed on the input signal. To perform other coding, such as spatial multiplexing, each fragment converter is consists of one transformer only. Multiple bits streams can be transmitted simultaneously by having multiple instances of the system as shown in Figure 8. Each instance is being assigned with a subset of transmitting antennas. Furthermore each bits stream can be employed with different type of transformation.

With the use of the system as shown in Figure 8, spatial multiplexing and transmit spatial diversity can be facilitated. Let assume the system is to be employed in a m_R*n_a antenna system, with $m_R >= n_a$. m_R is the number of received antenna and n_a is the number of transmit antenna.

To transmit a bits stream using spatial multiplexing technique, the system has to be configured with $n_f = n_g$, as shown in Figure 10. If the number of transformer in each fragment converter is fixed, then

the gate of the Transformers that are associated with B_1 are to be closed and the gate in Transformers that are associated with B_i, where $i = 2..n_a$ are to be opened. The Transformation unit in each Transformer is signaled to perform normal channel coding, for example convolution coding. The Frequency Assignment unit of Transformer is signaled to perform frequency coding at the base frequency that is associated with each fragment converter. The Antenna Assignment unit of Transformer is signaled to perform antenna assignment base on $(c + d - 1) \bmod n_a$, where c is the index of the sub stream that the current fragment is belonging to and d is the index of the branch. Finally, the bits steam that is to be transmitted is converted into the form that is required by the system as shown in Figure 5. With all the setup being done, at each transmission time slot, new segments of all sub streams are fed into the system to produce transmission signal. This mode is used to increase the transmission rate.

To transmit a bits stream using space-time block coding in order to achieve transmit spatial diversity, the system has to be configured with $n_f = n_g$, as shown in Figure 11. The gate of all Transformers is to be time controlled and a new segment of all sub streams are transmitted after n_d instances of transmission time slot, where n_d is the degree of transmit spatial diversity. For example, to apply Alamouti coding scheme on a 2*2 antenna system with the system shown in Figure 11, which is having 2 degree of transmit spatial diversity, the first step is to divide the bit stream into two sub

streams. Then at each first transmission time slot, the gate of Transformer that is associated with b_1 branch in a fragment converter is to be closed and the gate of Transformer that is associated with b_2 branch in a fragment converter is to be opened. The Transformation unit of Transformer is signaled to perform normal channel coding, for example convolution coding. The Frequency Assignment unit of Transformer is signaled to perform frequency coding at the base frequency that is associated with each instant of SYSTEM P. The Antenna Assignment unit of Transformer is signaled to perform antenna assignment base on $(c + d - 1) \bmod n_a$, where c is the index of the sub stream that the current fragment is belonging to and d is the index of the branch. At the next transmission time slot, the gate of Transformer that is associated with b_1 branch in fragment converter is to be opened and the gate of Transformer that is associated with b_2 branch in fragment converter is to be closed. The Transformation unit of Transformer that is used to process the first sub stream is signaled to perform X^* on the input signal X. The Transformation unit of Transformer that is used to process the second sub stream is signaled to perform $-Y^*$ on the input signal Y. The Frequency Assignment and Antenna Assignment units are performing the same operation as it is in the first transmission time slot. A new segment of a sub streams is fed into the system for every two transmission time slots.

To transmit a bit stream using space-frequency block coding in order to achieve transmit spatial diversity, the system has to be configured

with $n_g = n_d * n_f$, as shown in Figure 12, w here n_d is set to 2. The gate of all Transformers is to be closed at all time and at each transmission time slot, new segments of all sub streams are fed into the system to produce transmission signal. The Frequency Assignment unit in Transformer is signaled to perform frequency coding on the signal base on (b + d * f), where b is the base frequency that is associated with a fragment converter, d is the index of the branch in the SYSTEM Q that the Transformer is associated with and f is the frequency different between the two frequency set. The Transformation unit and Antenna Assignment unit are to perform the same operation as the example mentioned above. Transmit spatial diversity is used to increase the SNR of a transmitted signal.

Spatial Multiplexing can be combined with Transmit Spatial Diversity for multiple antenna system where the number of transmit antenna that is more than 3 transmit antennas and it is not a prime number. First, the number of antenna is to be factorized into the form of $n_d * n_e$, where n_d and n_e are not equal to 1. n_d is the degree of transmit spatial diversity and n_e is the number of instances of the system as shown in Figure 8 are to be created. Each instance of the system is associated with a distinct set of antennas. Each antenna set consists of n_d antennas.

In multiple antennas system, multiple antennas can be active in the same frequency at the same time to facilitate spatial parallel transmission, with the limitation that the number of transmitting

antennas cannot be greater than the number of receiving antennas. In order for receiver to receive and decode those spatial parallel transmissions, each individual antenna is required to be trained. In the training process, the transmitter transmits a known sequence and the receiver can base on the received signal and the known sequence to estimate the channel that is being used. Figure 13 shows a format for physical protocol data unit that consists of a PLCP header and a PSDU. PLCP header contains some known sequences and signal information that is used by the receiver to perform synchronization, channel training and reception setup in order to facilitate the reception of PSDU. Figure 14 shows a new format for physical protocol data unit that is to be used in multiple antenna system to facilitate spatial parallel transmission.

It consists of Legacy Preamble and Signal (601), High Throughput Signal (602), High Throughput Training Sequences (603) and Service Data Unit (604). The High Throughput Signal field consists of 3 sub fields, which are Antenna Count (611), Mode (612) and Duration (613). The Antenna Count is used to indicate the number of transmit antenna that will participate in the PSDU transmission. The Mode subfield is used to indicate the transformation mode that is to be employed on the PSDU for the transmission. The Duration subfield is used to indicate the duration that is required to complete the transmission of the whole PSDU.

The Mode subfield consists of an entry for each available frequency

set. Each entry (620) can be further subdivided into multiple subfields, such as SM (621), STBC (622), SFBC (623), Modulation Type (624) and Coding Rate (625) as shown in Figure 14. The SM field is used to indicate the spatial multiplexing technique that is being employed in the transmission. The STBC field consists of two subfields, which are T_Mode (631) and T_Degree (632). The T_Mode subfield is used to indicate if Space-Time Block Code or the type of Space-Time Block Code that is being employed in the transmission. The T_Degree subfield is used to indicate the number of transmission time slots that are being employed for coding a transmission signal. The SFBC field consists of two subfields, which are F_Mode (633) and F_Degree (634). The F_Mode subfield is used to indicate if Space-Frequency Block Code or the type of Space-Frequency Block Code that is being employed in the transmission. The F_Degree subfield is used to indicate the number of distinct frequency sub carriers that are being employed for coding a transmission signal. The Modulation Type is used to indicate the type of modulation scheme that is being employed on PSDU for transmission. The Coding Type & Rate is used to indicate the coding that is being employed on PSDU for transmission. The Duration field is used to indicate the transmission time required to transmit a complete PSDU attached using the mode as indicated. The Training Sequences consists of n number of known sequence, where n is the number as indicated in the Antenna Count Field. Each known sequence is being transmitted by one antenna at an instant of time only.

In a transmission of a PPDU, Legacy Preamble & Signal and High Throughput SIGNAL are to be transmitted by an antenna that is marked with index 1 only. After synchronization, if the SIGNAL in the Legacy Preamble & Signal indicated that the received PPDU is for high throughput, then the High Throughput SIGNAL is to be interpreted. After decoding the High Throughput SIGNAL, the end of training sequences and the end of the transmission are determined. If the transformation setting as indicated by the Mode field is not supported by the receiver, then the receiver will not interpret the remaining fields and remain ideal until the end of the transmission. After the transmission of Legacy Preamble & Signal and High Throughput SIGNAL, each transmitting antenna take turn to transmit a fix training sequence. Upon receiving a training sequence that is transmit by an antenna, a column of a matrix that representing the frequency response of the channel is constructed. The dimension of the matrix is $n_R * n_T$, where n_R is the number of receiving antennas that the receiver have and n_T is the number of antennas that are being used in the transmission as indicated in the Antenna Count field. Each column of the matrix is constructed in the sequential order. The matrix is then used to remove the frequency response of the channel from the received data signal in order to facilitate decoding of the transmitted signal.

In the multiple antennas system, each antenna is an instant of medium resource. Hereby it is denoted as Medium Resource Type I.

In a transmission, the maximum instances of Medium Resource Type I that can be utilized are determined by the minimum number of antenna of all receiving entities. A transmission can consist of a single stream or multiple streams that are targeted to a receiving entity or multiple receiving entities. In OFDM system, each distinct set of frequency sub-carriers can be formed and visualized as an instant of medium resource. Hereby it is denoted as Medium Resource Type II. The maximum instances of Medium Resource Type II is determined by the number of distinct set of frequency sub-carriers that are being formed or configured during initialization and setup. The total number of medium resources that are available in a transmission that combining the two above mentioned systems are equal to $n_{TypeI} * n_{TypeII}$. n_{TypeI} is the maximum instances of Medium Resource Type I that are available in a transmission. n_{TypeII} is the maximum instances of Medium Resource Type II that are available in the system. Each instant of medium resource in the combined system can be identified by a Resource ID, which consists of two subfields: Frequency Set ID (702) and Antenna Index (703). Frequency Set ID is a unique ID that uniquely identifies each instant of Medium Resource Type II. Antenna Index is an index used to identify transmitting antenna of a transmission. So a Resource ID can uniquely identify a transmitting antenna that is transmitting using all frequency sub-carriers belonging to a frequency set that is identified by the Frequency Set ID.

In multiple antennas & OFDM system, parallel transmissions of up to

the number of instances of medium resources available are permitted. A transmission collision is being encountered when same instant of medium resource is being utilized by two transmission entity at the same instant of time. Figure 15 shows a Medium Resource Dedication frame format that is used to coordinate medium resource utilization in order to avoid collision. It consists of n number of Resource Dedication field, where n is the number of medium resource dedication and is must not be greater than the number of medium resource instances available. Each Resource Dedication field consists of two subfields, which are Resource ID (732) & Transmitter ID (733). A special value, which is pre-determined, in any of the two subfields indicates that all medium resources of that type are being dedicated to the transmitting entity. If both subfields are being assigned with the special value, then the transmitting entity is being dedicated with all medium resources of all types. The Transmitter ID is the entity that is being dedicated to use the resources that are being identified by Resource ID. In a scenario where all station is having the same number of transmit antenna, the Medium Resource Dedication frame can be used to dedicate all medium resources to a station for a specific duration by using one Resource Dedication field and set Resource ID to contain the special value. In another scenario where station A and medium resource coordinator have two transmit antennas but station B & C has only one transmit antenna and two distinct frequency sub-carrier set are available for all station, the Medium Resource Dedication frame can be used to dedicate frequency sub-carrier set 1 with antenna index 1

& 2 to station A as well as dedicate frequency sub-carrier set 2 with antenna index 1 to station B and frequency sub-carrier set 2 with antenna index 2 to station C. If this dedication is done, those stations that are being dedicated with antenna index 1 are responsible to transmit Legacy Preamble & Signal and High Throughput Signal on the frequency sub-carrier set that are being dedicated.

Medium resource dedication required scheduling in order to meet the QoS requirement of all traffic streams that have registered their QoS expectation with medium resource coordinator. First is to determine the number of instances of medium resources that can be utilized by each individual station and denoted it by R_i. Each resource is uniquely identified by Frequency Set ID + Antenna Index. At each resource allocation, each antenna is given an index. The total of index used to identify an antenna cannot be greater then the number of antenna at AP. Next is to compute the minimum of all delay tolerance at MAC & PHY for all data units that are originated from the $station_i$ and denote it by $DBmin_i$. Followed by determining the minimum number of dedication required for each station within $DBmin_i$ and denote it by $Mmin_i$. This can be a pre-configured value that is determined by network administrator or abstract from the QoS requirement or retransmission requirement of individual station. Then compute the number of dedication required within $DBmin_i$ for each station in order to satisfy QoS requirement of respective station and denote it by N_i, where N_i is equal to $max(Mmin_i, Nmin_i)$. $Nmin_i$ is the

minimum number of dedication required by $station_i$ within $DBmin_i$, which is computed by $\left\lceil \frac{D_i}{TXOPmax_i} \right\rceil$, where $TXOPmax_i$ is the maximum duration that is allowed or pre-configured for each instant of dedication. D_i is the medium occupancy time that is required within the $DBmin_i$, which is computed by $\frac{R_i * DBmin_i}{M_i} * T_i$, where R_i = Service Data unit generation rate for $station_i$, M_i = Total size of service data unit in a transmission unit that is initiated by $station_i$ and T_i = The transmission time required to complete a transmission unit by $station_i$ that only utilize a single instant of resource. A transmission unit can consist of a single or multiple protocol data units and including necessary acknowledgement for those protocol data units. Each protocol data unit can consist of a single or partial or multiple service data units.

After N_i, $Mmin_i$ & $DBmin_i$ are being computed, a dedication cycle, C that must be greater than or equal to $\min(\frac{DBmin_i}{N_i})$ for all i and less than or equal to $\min(\frac{DBmin_i}{Mmin_i})$ for all i, is to be determined. A means to determine a value for C is to choose the maximum value of $\frac{DBmin_j}{N_j}$ for a j that is still less than or equal to $\min(\frac{DBmin_i}{Mmin_i})$ for all i. After a dedication cycle is being determined, the number of dedication that

is required within a dedication cycle interval, NC_i and the duration of each dedication, $TXOP_i$, are to be computed. If all station can utilise the same number of resources (R_i = R_j for i <> j), then for each $station_i$ set RC_i to 1 and re-compute the medium occupancy time required within $DBmin_i$ with T_i = The transmission time required to complete a transmission unit by $station_i$ that utilize R_i instances of resource. Once the medium occupancy time required within $DBmin_i$ is updated, N_i is also needed to be updated. If not all station can utilise the same number of resources, then set RC_i = R_i. The computation for the number of dedication required within a dedication cycle interval is $NC_i = C * \frac{N_i}{DBmin_i}$ and the duration of each dedication is $TXOP_i = \frac{D_i}{N_i}$.

The schedule being generated by the above method is the number of medium resource dedication and the duration of each dedication within each dedication cycle for each station. The schedule is to be combined with RC_i of each station in order to determine the number of Medium Resource Dedication frame to be generated.

First is to determine the total number of resources that are available for dedication, R. Then for each dedication interval, perform the medium dedication frame generation operation until the requirements of all transmitting entity are being fulfilled. The operation started by initialising R_T, which is the number of resources that are still available, to R and N_{Ti}, which is the number of medium resource dedication required for $station_i$ within a dedication cycle interval, to NC_i. For each transmitting entity, if N_{Ti} is greater than zero, then

choose the minimum value among N_{Ti}, RC_i and R_T and assign it to T. T is used to indicate the numbers of units of medium resource dedication are to be dedicated to the transmitting entity. If the transmitting entity is having RC_i equal to 1, then a unit of medium resource dedication consists of R_i instances of medium resource. If the transmitting entity is having RC_i equal to R_i, then a unit of medium resource dedication is corresponding to an instant of medium resource. Then, subtract T from N_{Ti} and construct Resource Dedication fields, which indicating the medium resources being allocated to the transmitting entity, that are to be incorporated into Medium Resource Dedication frame. After Resource Dedication fields are being generated, computed the number of medium resources that are still not being dedicated. If RC_i is not equal to R_i, then R_T is equal to zero, else subtract T from R_T. If R_T is zero after the operation, then reset R_T back to R and release the medium resource dedication frame that is being constructed. The following is a pseudo code for the procedure for generating Medium Resource Dedication frame:

```
RT = The number of resources that are available for dedication, R;

Do {

    more = Ftase;

    For (i = 0; i < n; i++)

        NTi = NCi;


    For (i = 0; i < n; i++) {

        If (NCi > 0) {
```

```
T = min(NC_i, RC_i, R_T)
NC_i = NC_i − T;
If (NC_i > 0) then more = True;
Construct a Resource Dedication field that is to be transmitted by Medium
Resource Dedication Frame;
If (RC_i <> R_i)
    R_T = 0;
Else
    R_T = R_T − T;

If (R = 0) {
    Release the Medium Resource Dedication frame for transmission;
    R_T = R;
}
}
}
} Until more = False;
```

[Industrial applicability]

The present invention can be used for the method and apparatus to facilitate categorization of medium resources for multi-antenna wireless system.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1. A flow diagram to illustrate the processes that are required to achieve high throughput wireless transmission.

Figure 2: A block diagram of an OFDM transmitter.

Figure 3: A block diagram of an OFDM receiver.

Figure 4: An overview of all building blocks for a transformer.

Figure 5: Illustration of the relationship between stream, sub streams, segments and fragments as well as fragment labeling.

Figure 6: An overview for the operations of Bits Stream Divider.

Figure 7: A flowchart for the steps to be performed to generate fragments.

Figure 8: An architecture diagram for a system to convert bits stream into transmission signals.

Figure 9: An overview of the operations to convert bits stream into transmission signals.

Figure 10: An example illustrating the use of the system to perform spatial multiplexing for generating transmission signal.

Figure 11: An example illustrating the use of the system to perform space time coding for generating transmission signal.

Figure 12: An example illustrating the use of the system to perform space frequency coding for generating transmission signal.

Figure 13: A frame format of Physical protocol data unit.

Figure 14: A new frame format of Physical protocol data unit to facilitate parallel transmission in multiple antenna system.

Figure 15: A frame format that used to perform medium resource dedication

【書類名】外国語図面

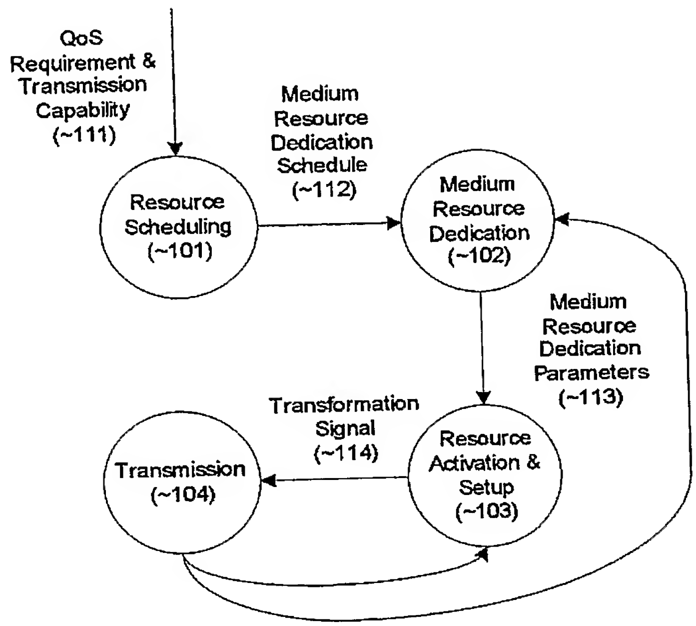
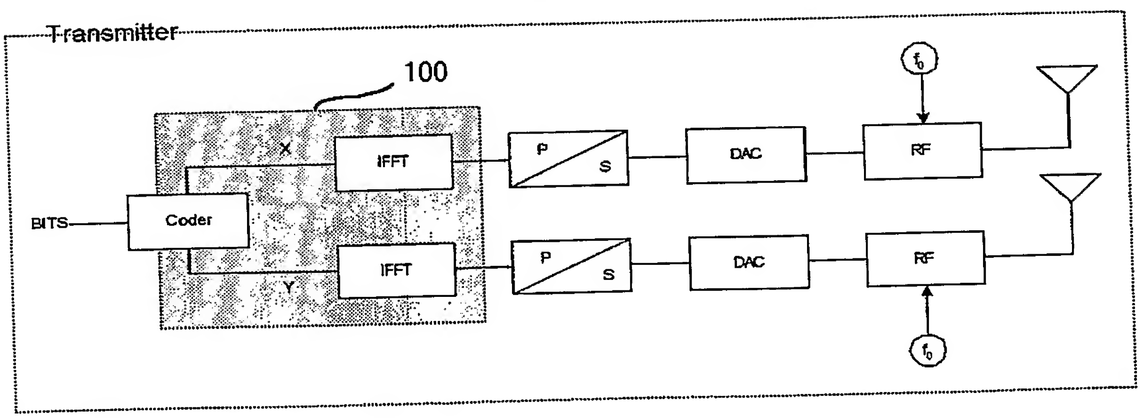


Figure 1

Figure 2



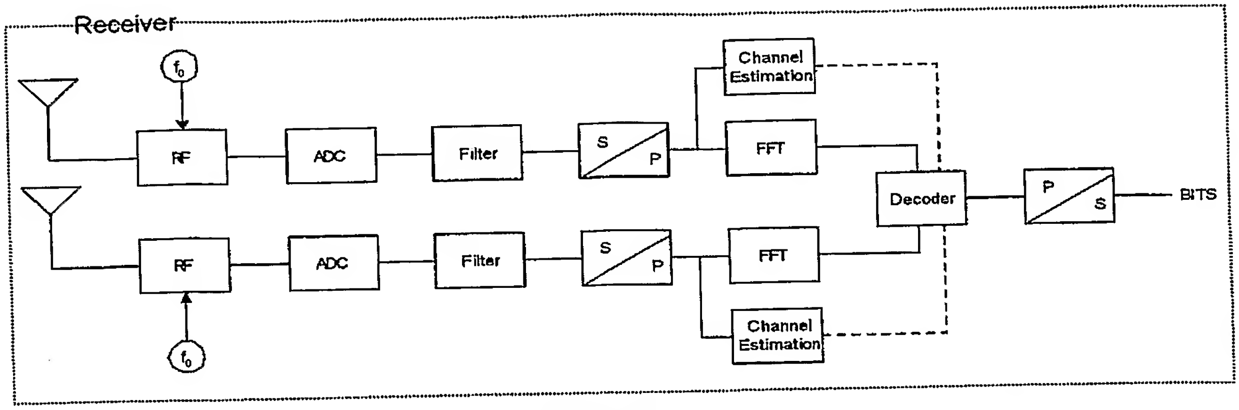


Figure 3

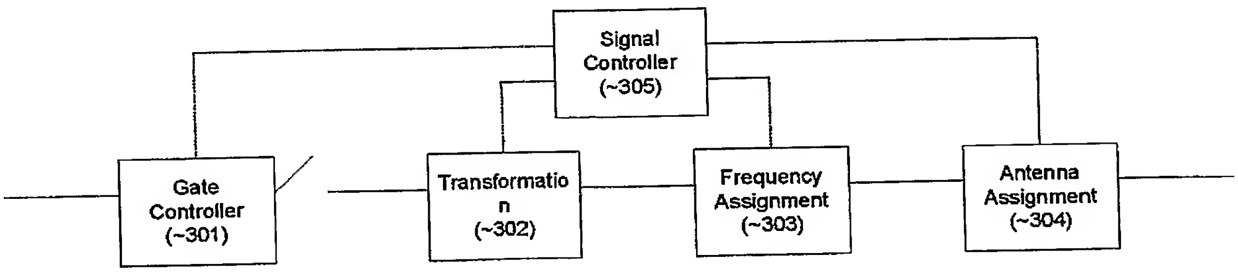


Figure 4

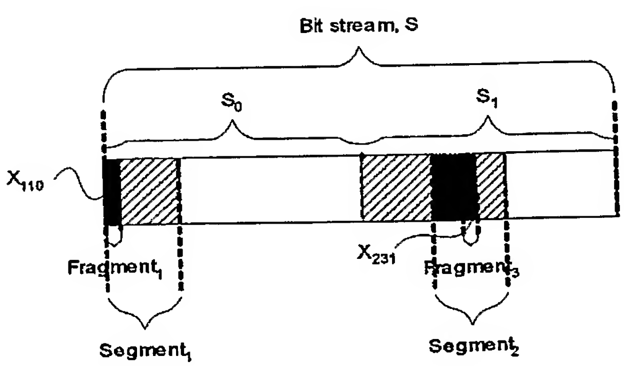


Figure 5

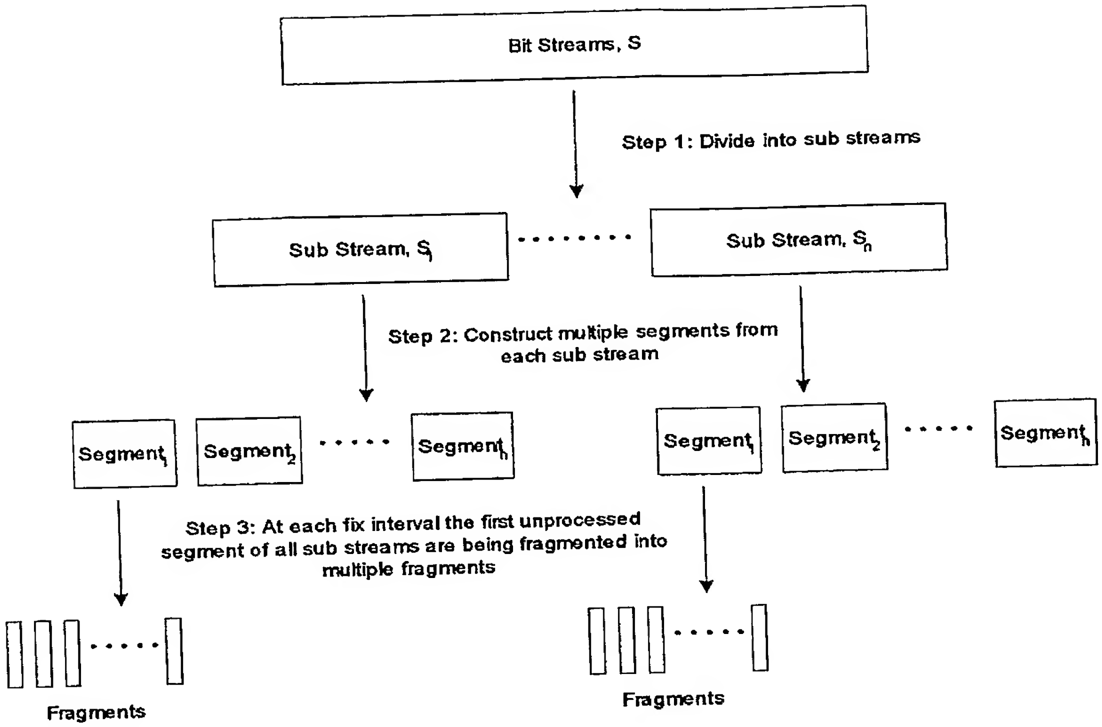

Bit Streams, S
Step 1: Divide into sub streams
Sub Stream, S_1
Sub Stream, S_n
Step 2: Construct multiple segments from each sub stream
$Segment_1$
$Segment_2$
$Segment_n$
$Segment_1$
$Segment_2$
$Segment_n$
Step 3: At each fix interval the first unprocessed segment of all sub streams are being fragmented into multiple fragments
Fragments
Fragments

Figure 6

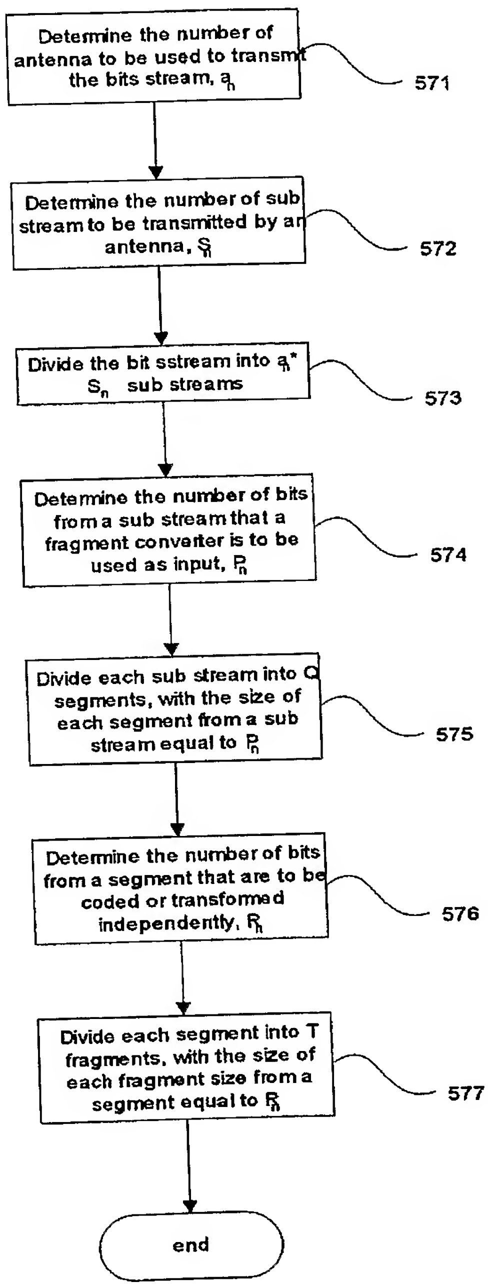

Determine the number of antenna to be used to transmit the bits stream, a_n
571
Determine the number of sub stream to be transmitted by an antenna, S_n
572
Divide the bit sstream into a_n* S_n sub streams
573
Determine the number of bits from a sub stream that a fragment converter is to be used as input, P_n
574
Divide each sub stream into Q segments, with the size of each segment from a sub stream equal to P_n
575
Determine the number of bits from a segment that are to be coded or transformed independently, R_n
576
Divide each segment into T fragments, with the size of each fragment size from a segment equal to R_n
577
end

Figure 7

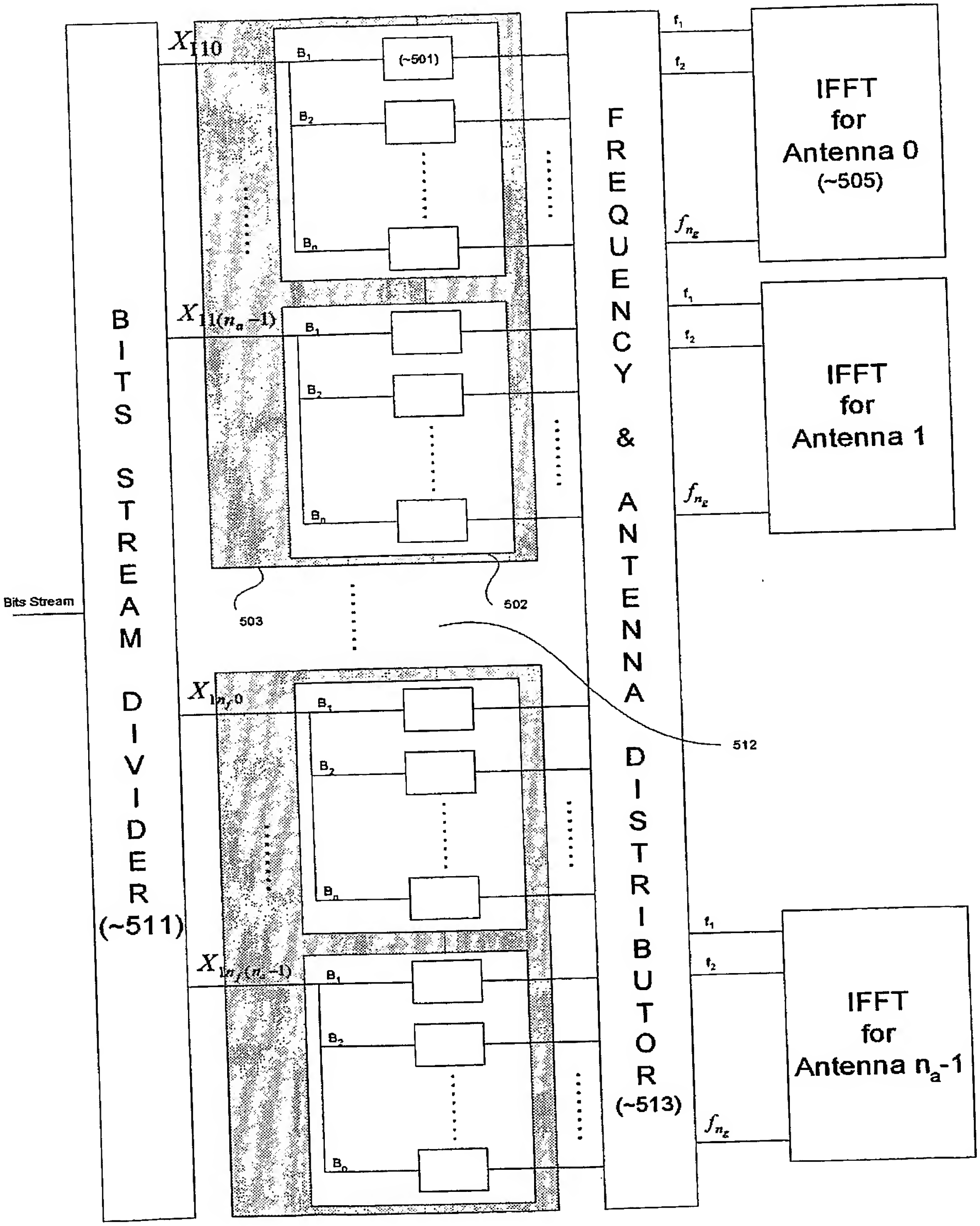

BITS STREAM DIVIDER (~511)
Bits Stream
X_{110}
$X_{11(n_a-1)}$
X_{1n_f0}
$X_{1n_f(n_a-1)}$
B1
B2
Bn
(~501)
503
502
512
FREQUENCY & ANTENNA DISTRIBUTOR (~513)
f1
f2
f_{n_g}
IFFT for Antenna 0 (~505)
IFFT for Antenna 1
IFFT for Antenna n_a-1

Figure 8

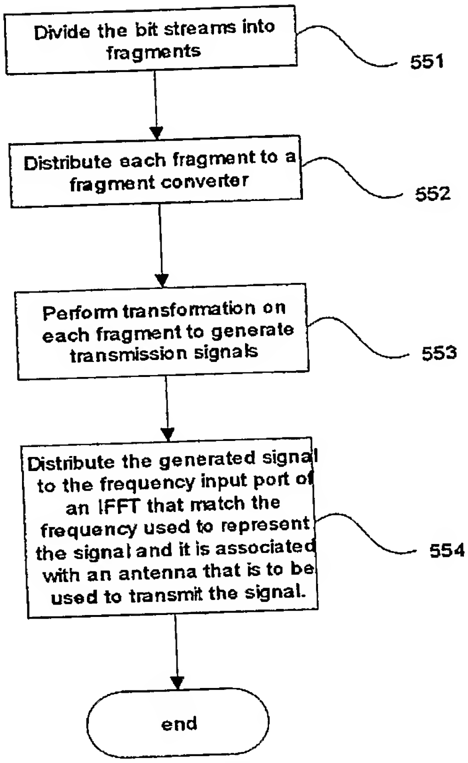

Divide the bit streams into fragments
551
Distribute each fragment to a fragment converter
552
Perform transformation on each fragment to generate transmission signals
553
Distribute the generated signal to the frequency input port of an IFFT that match the frequency used to represent the signal and it is associated with an antenna that is to be used to transmit the signal.
554
end

Figure 9

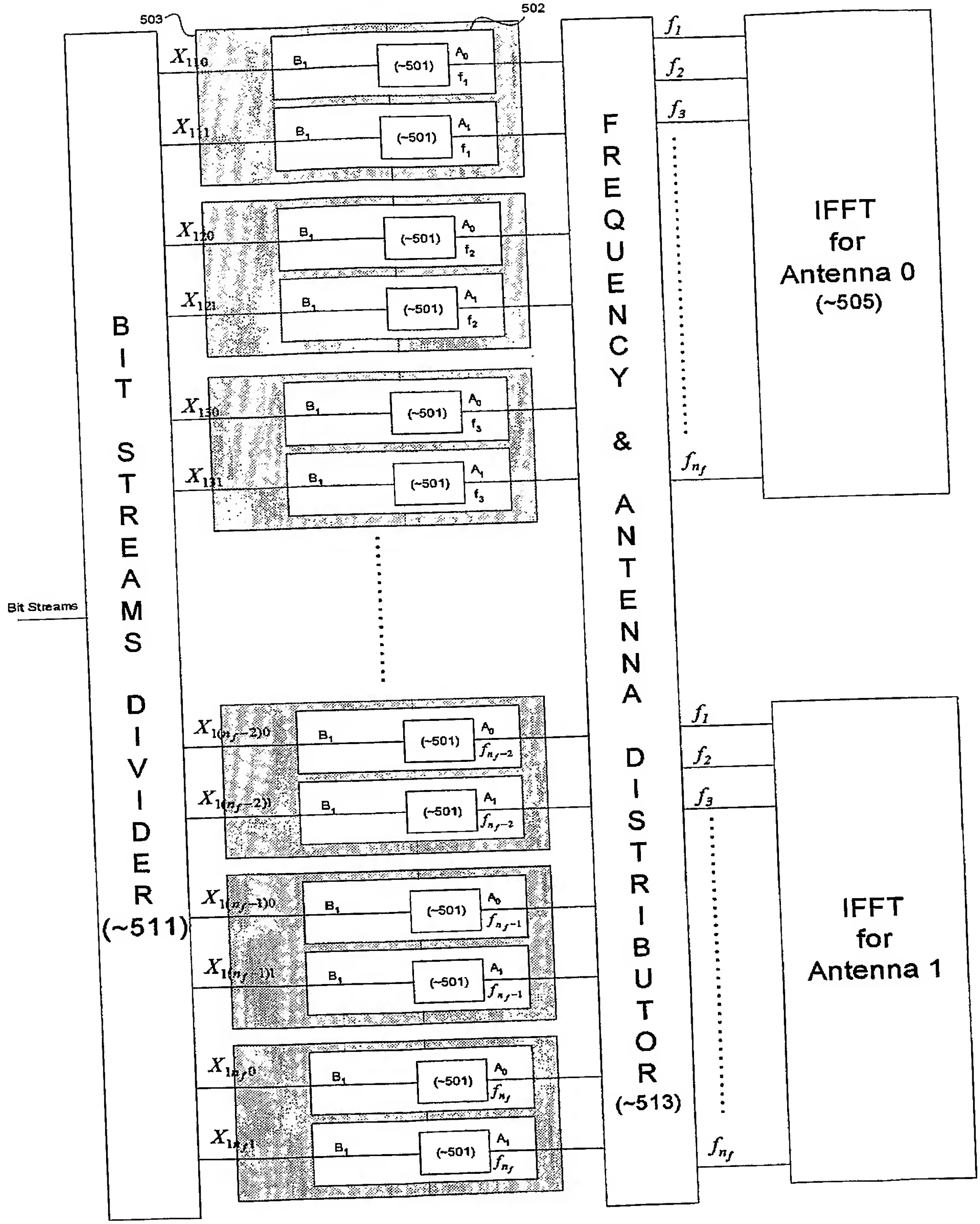

503
502
Bit Streams
BIT STREAMS DIVIDER (~511)
FREQUENCY & ANTENNA DISTRIBUTOR (~513)
IFFT for Antenna 0 (~505)
IFFT for Antenna 1
(~501)

Figure 10

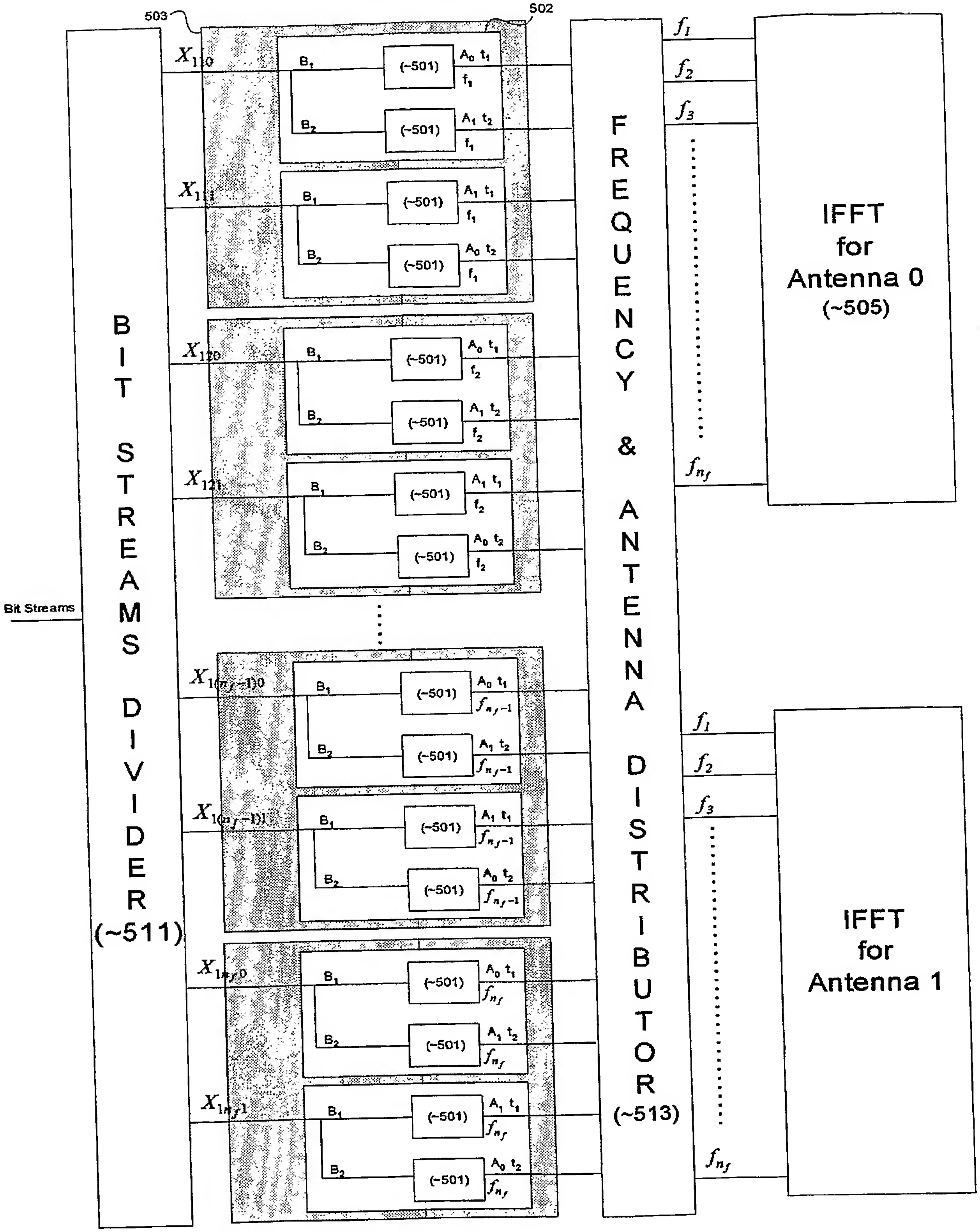

503
502
Bit Streams
BIT STREAMS DIVIDER (~511)
FREQUENCY & ANTENNA DISTRIBUTOR (~513)
IFFT for Antenna 0 (~505)
IFFT for Antenna 1
(~501)
B1
B2
A0 t1
A1 t2
A1 t1
A0 t2

Figure 11

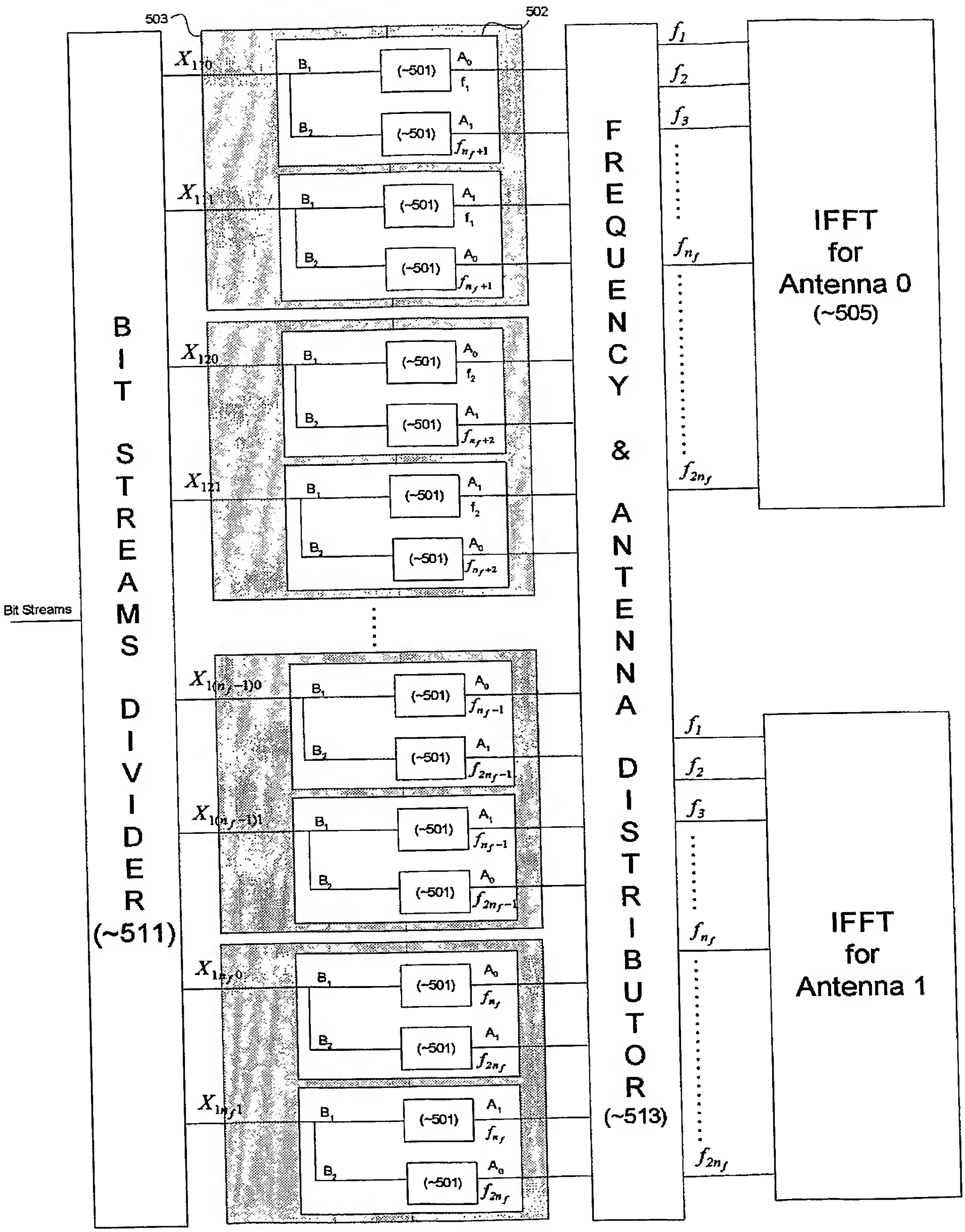

503
502
Bit Streams
BIT STREAMS DIVIDER (~511)
X_{110}
X_{111}
X_{120}
X_{121}
$X_{1(n_f-1)0}$
$X_{1(n_f-1)1}$
X_{1n_f0}
X_{1n_f1}
B₁
B₂
(~501)
A₀
A₁
FREQUENCY & ANTENNA DISTRIBUTOR (~513)
f_1
f_2
f_3
f_{n_f}
f_{n_f+1}
f_{n_f+2}
f_{n_f-1}
f_{2n_f-1}
f_{2n_f}
IFFT for Antenna 0 (~505)
IFFT for Antenna 1

Figure 12

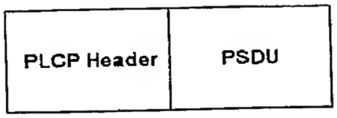


Figure 13

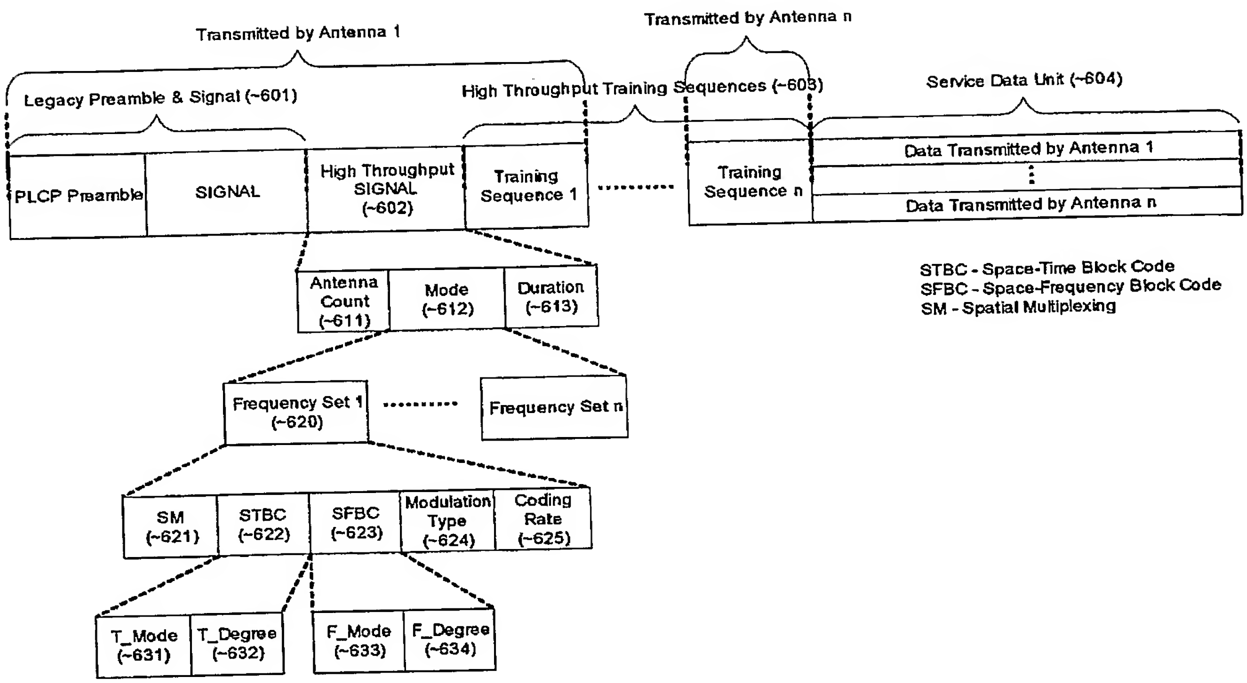


Figure 14

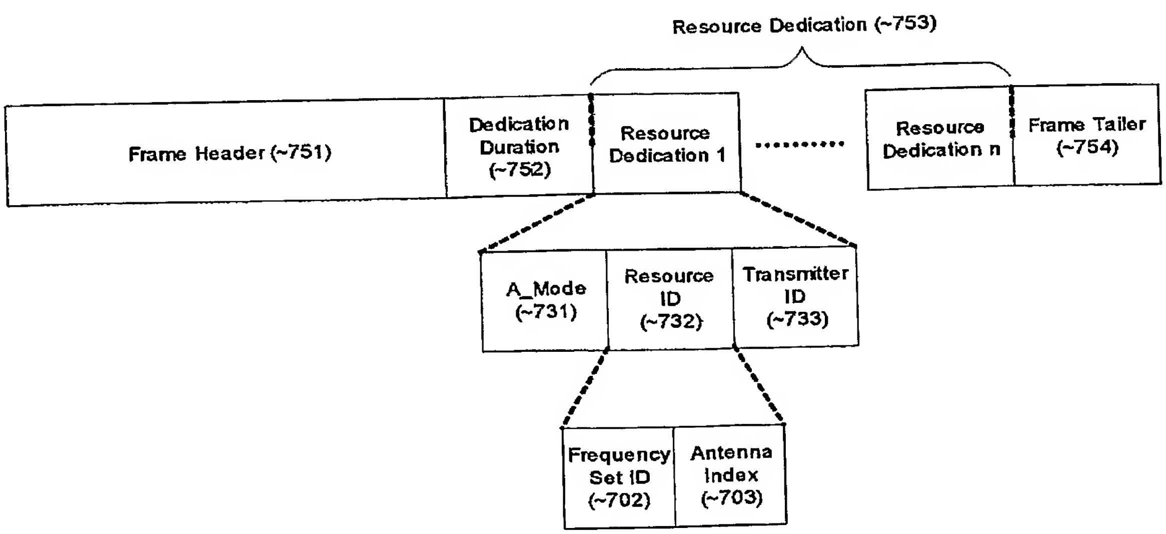


Figure 15

【書類名】外国語要約書

ABSTRACT OF THE DISCLOSURE

[Object]

To improve the throughput for a wireless transmission is the object.

[Means for solving the object]

Multiple antennas are activated in the same frequency at the same time to facilitate parallel transmission. A systematic processes are provided to achieve high throughput transmission.

特願２００４－０５３８６０

出　願　人　履　歴　情　報

識別番号　　　　　　　［０００００５８２１］

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